Library.

Marine Bird Distribution in Lancaster Sound and Potential Impacts of Marine Transport

by R. W. Prach and A. R. Smith

Canadian Wildlife Service
Western and Northern Region

MARINE BIRD DISTRIBUTION IN LANCASTER SOUND

AND

POTENTIAL IMPACTS OF MARINE TRANSPORT

by

R. W. Prach and A. R. Smith

CANADIAN WILDLIFE SERVICE

Western and Northern Region

Edmonton, Alberta

December 1985

TABLE OF CONTENTS

	Page
List of Tables	ii
List of Figures	ii
ACKNOWLEDGMENTS	1
1. SUMMARY	2
2. INTRODUCTION	3
2.1 Biological and Industrial Values	3
2.2 Survey Coverage	5
2.3 The Biological Role of Ice	9
2.4 Possible Environmental Effects of Tanker Traffic on Marine Birds	10
2.5 Knowledge Gaps	11
3. SPECIES ACCOUNTS	13
3.1 Northern Fulmar	13
3.2 Oldsquaw	15
3.3 Eider	15
3.4 Glaucous Gull	17
3.5 Thayer's Gull	18
3.6 Ivory Gull	18
3.7 Black-legged Kittiwake	20
3.8 Arctic Tern	22
3.9 Thick-billed Murre	22
3.10 Dovekie	24
3.11 Black Guillemot	24
4. LITERATURE CITED	28

List of Tables

1.	Minimum densities used to delineate areas of concentration	4
2.	Northern Fulmar Colonies	14
3.	Black-legged Kittiwake Colonies	21
4.	Thick-billed Murre Colonies	26

List of Figures

1.	Places named in the text	6
2.	Temporal coverage: Dates of surveys	7
3.	Geographical area represented in the text	8
4.	Locations of the fast-ice edge in Lancaster Sound from 1964 to 1979	8
5.	Colony locations and seasonal distribution of Northern Fulmars	14
6.	Seasonal distribution of Oldsquaws	16
7.	Seasonal distribution of Eiders	16
8.	Colony locations and seasonal distribution of Glaucous Gulls	19
9.	Colony locations of Thayer's Gulls and seasonal distribution of Thayer's and Ivory Gulls	19
10.	Colony locations and seasonal distribution of Black-legged Kittiwakes	23
11.	Colony locations and seasonal distribution of Arctic Terns	23
12.	Colony locations and seasonal distribution of Thick-billed Murres	26
13.	Seasonal distribution of Dovekies	27
14.	Colony locations and seasonal distribution of Black Guillemots	27

ACKNOWLEDGMENTS

We would like to thank Roger Edwards, Head of the Ecological Assessment Section of the Canadian Wildlife Service, Western and Northern Region for his helpful comments on the manuscript. We also thank Susan Popowich for the cover design and art work, the drafting, and other support services in preparing the manuscript and publishing the report.

1. SUMMARY

The available information on the occurrence and distribution of marine birds in Lancaster Sound is summarized.

Although survey data to fully document the seasonal distributions of marine birds in Lancaster Sound are incomplete, there is sufficient information to strongly suggest that oil pollution resulting from development and transportation of oil through that portion of the Northwest Passage will adversely affect the survival of some populations whose breeding areas to date have been relatively free from oil pollution.

Significant portions of the areas' breeding populations gather in small areas of open water, particularly during spring migration in most years and throughout the breeding season in years with heavy ice conditions. During such a year, birds are likely to concentrate in those limited areas of open water where oil is also likely to collect. Any bird contaminated by oil in such conditions will most likely die. In addition, survival of some populations could be further jeopardized by changes in food availability caused by disruption or contamination of feeding areas associated with stable ice edges. There is no evidence to suggest that available oil spill countermeasures can mitigate these adverse effects.

The current level of understanding of arctic marine ecosystems does not permit biologists to accurately predict precise effects of particular oil spills nor is the knowledge of marine bird distribution adequate to permit informed decisions on the effective deployment of any oil spill countermeasures which may be developed.

2. INTRODUCTION

This report summarizes the information on the temporal and geographical distribution of the more conspicuous marine bird species recorded on aerial surveys in Lancaster Sound; comments on the possible effects of large-scale transport of petroleum products by ice-breaking tankers on marine birds; and identifies gaps in the knowledge of the ecology of these birds.

The following sources form the basis for much of the text which follows: aerial surveys in the central Arctic (Alliston et al. 1976, Davis et al. 1974); aerial surveys of fast-ice edges in Barrow Strait (Bradstreet and Finley 1977); aerial surveys of sea bird colonies around Devon Island (Nettleship 1973); aerial surveys of western Lancaster Sound (Nettleship and Gaston 1978); and aerial surveys in eastern Lancaster Sound and western Baffin Bay (Johnson et al. 1976, McLaren 1982). Additional references are cited in the text.

In presenting the data in the figures that follow, certain criteria were used to define areas of concentration. The densities for each species were chosen so as to be comparable among the sources analyzed. In addition, because the number of individuals varies greatly among species, and individual birds of all species may be widely distributed throughout Lancaster Sound, it was necessary to choose different densities in order to highlight the areas of relative importance for each species. The densities used to produce the distribution maps are shown in Table 1.

2.1 Biological and Industrial Values

Lancaster sound has several features which attract the widely divergent and often conflicting interests of government, industry, and the general public. The Sound has special biological characteristics which make it unique in North America and perhaps the world. More than three million marine birds of some 30 species nest adjacent to or feed in the Sound during the open water season. At least 10 species of marine mammals including three permanent residents occur there and the productive waters provide food and refuge during the summer for more than half of the eastern Arctic's marine birds, one-third of North Americas's belugas (Delphinapterus leucas) and possibly 85 percent of the world's narwals (Monodon monoceros).

Lancaster Sound itself contains several geological structures that may hold considerable deposits of oil and gas. There is considerable pressure from the public and private sectors of the oil industry to develop this basin.

Two commercial mineral deposits in the Lancaster Sound region are being actively exploited: at Nanisivik on Baffin Island, and on Little Cornwallis Island. The lead-zinc mine at Nanisivik produces 150 000 tonnes of ore per year. The deposit on Little Cornwallis, containing reserves of more than 23 million tonnes, began production in 1982. Others such as the Mary River iron ore deposits on Baffin Island, estimated at 130 million tonnes, await development.

Table 1. Minimum densities (birds/km²) used to delineate areas of concentration.

Species	Minimum density (birds/km²)	Figure No.
Northern Fulmar	50	5
Oldsquaw	20	6
Eider	50	7
Glaucous Gull	20	8
Thayer's Gull	10	9
Ivory Gull	3	9
Black-legged Kittiwake	20	10
Arctic Tern	20	11
Thick-billed Murre	50	12
Dovekie	100	13
Black Guillemot	20	14

Marine transportation plays a significant part in all aspects of northern development. Lancaster Sound is a key link in the Northwest Passage: the most useful and probably only practicable shipping corridor to and from the high, central, and western Arctic. Lancaster Sound will be affected, not only by development within the region, but also by activities well beyond the Sound itself.

At present, shipping through Lancaster Sound is limited to fewer than 100 passages during the summer months when ice, weather, and light conditions are most favorable. However, year-round shipping of oil and gas through Lancaster Sound on a large scale is actively being considered by several oil companies and consortia in which government, through Pan Arctic and Petro Canada, has considerable holdings. A proposal to transport Beaufort Sea oil to market through Lancaster Sound was given conditional support by the Environmental Assessment Panel on the Beaufort Sea Development (FEARO Report No. 25) and the Minister of Indian Affairs and Northern Development has recently approved the proposal by Pan Arctic to ship crude oil from Cameron Island through Lancaster Sound. Mansfield (1983) estimates that 104 super-tankers passing through Lancaster Sound at a rate of one every 2.3 to 5.5 hours will be required by the end of the century to transport the oil and LNG from current development proposals in the high Arctic.

2.2 Survey Coverage

Figure 1 shows the location of the places named in the text. Figure 2 shows the time periods represented by the data reviewed in this report. Western Lancaster Sound was surveyed in each of three years from 1974 through 1976. Surveys were conducted from early June through August or September and are adequate to determine distribution during peak migration periods for most species during the years when surveys were done. Eastern Lancaster Sound was surveyed in 1976, 1978, and 1979. The surveys were conducted from early May through late September in 1976 and 1978 spanning most of the breeding and fledging periods for most species during those years; and from early May through mid-July in 1978.

The geographical area represented by the data in this report are shown in Figure 3. As can be seen, systematic coverage of the central portion of Lancaster Sound is lacking.

In addition to incomplete spatial coverage, it is highly unlikely that these surveys were conducted during weather conditions representative of all years in the Arctic. The extent and distribution of winter ice varies from year to year. As early as mid-January in some years, a fast-ice edge forms at various locations in Lancaster Sound and Barrow Strait (Fig. 4). The location of this fast-ice edge in Lancaster Sound appears to be an important factor in determining the spring and summer distributions of many marine birds throughout Lancaster Sound (Bain et al. 1977).

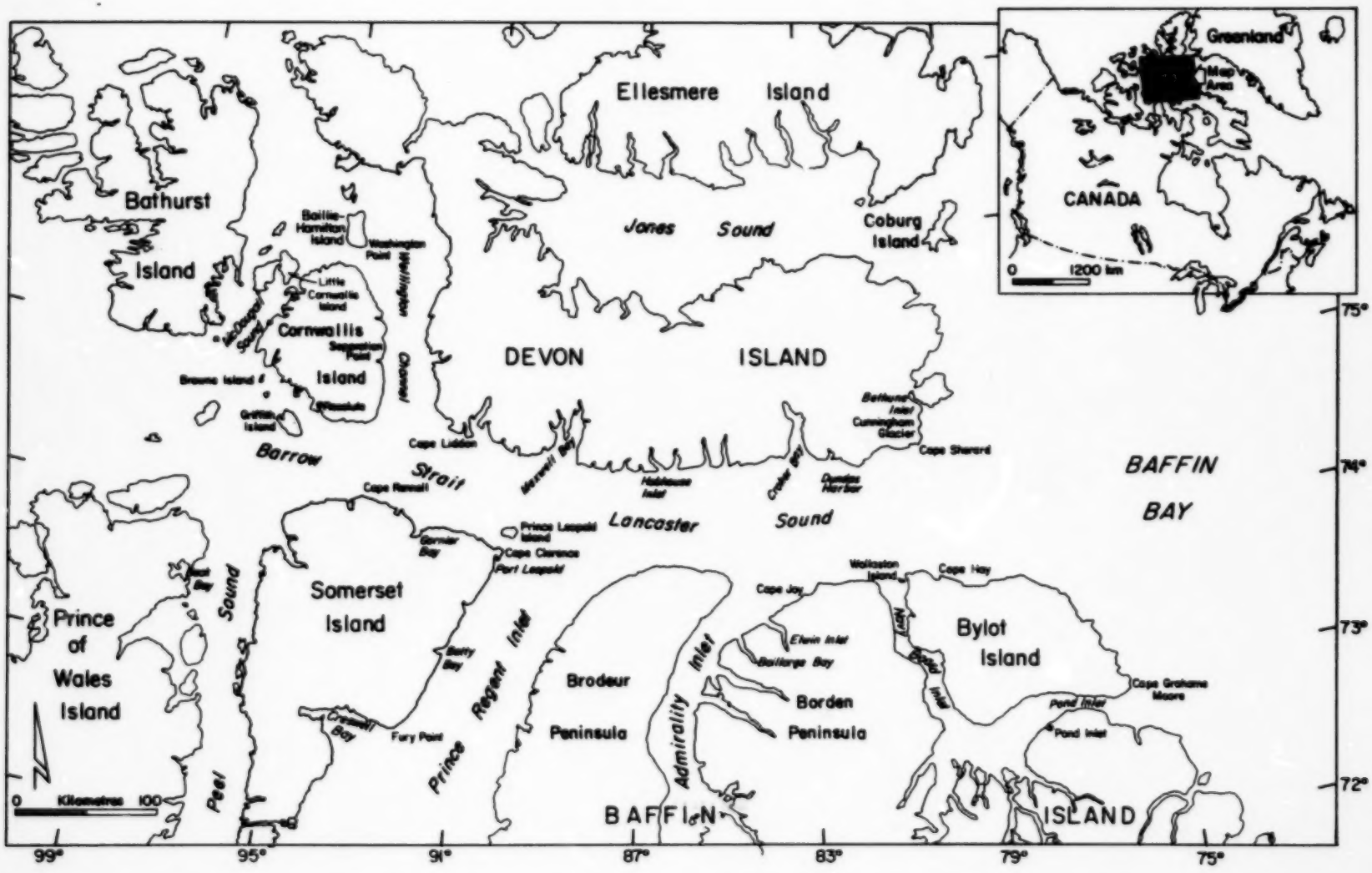


Figure 1. Places named in the text.

Figure 2. Temporal coverage: Dates of surveys.

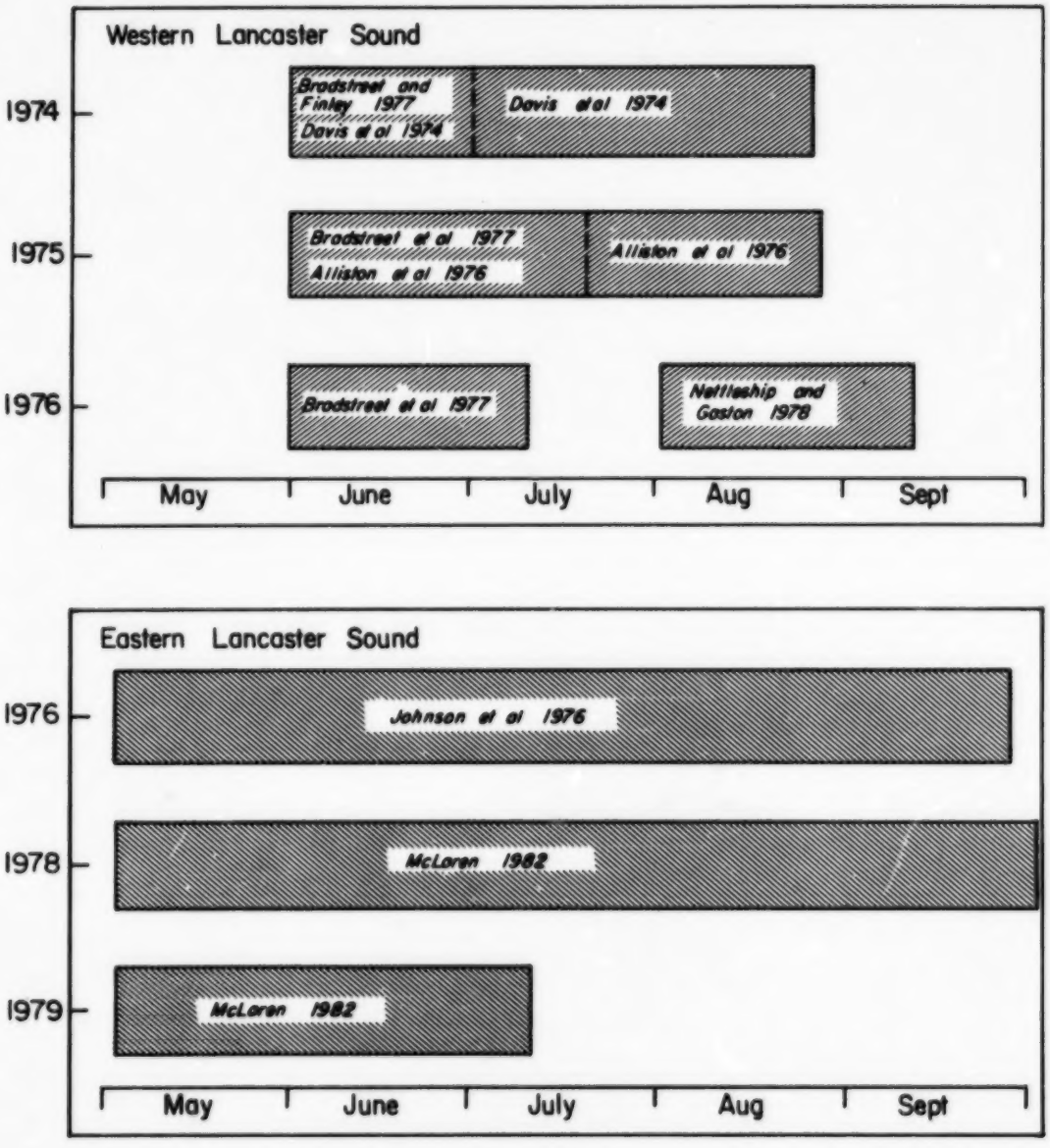


Figure 3. Geographical area represented in the text.

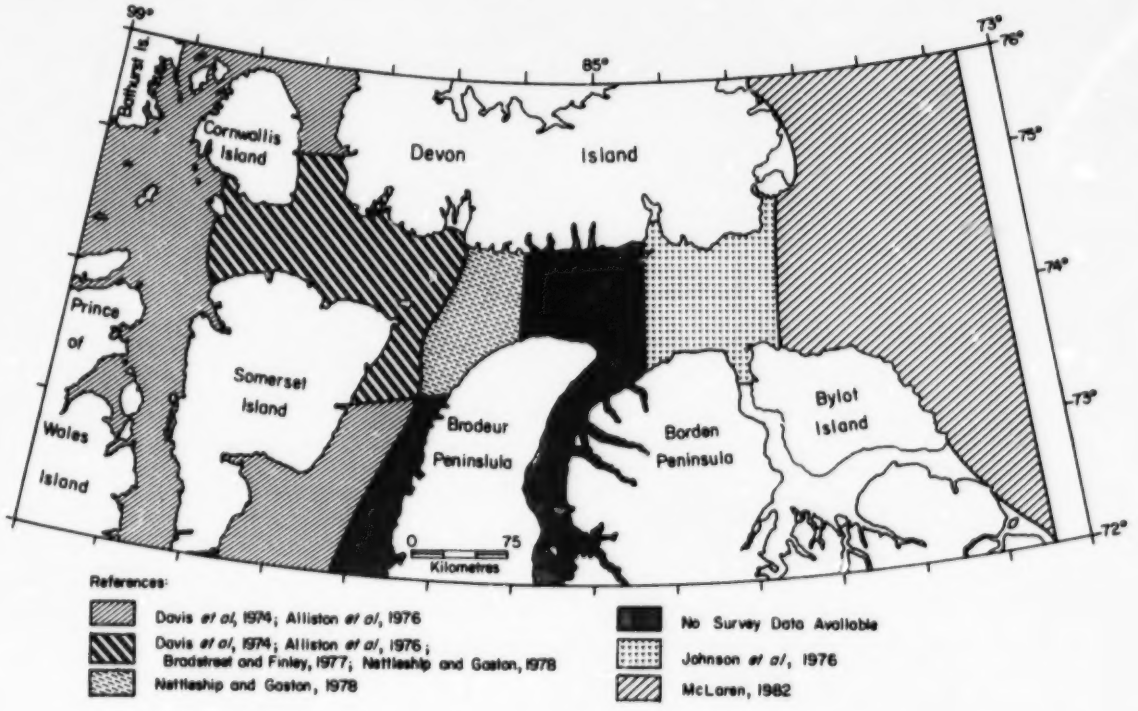
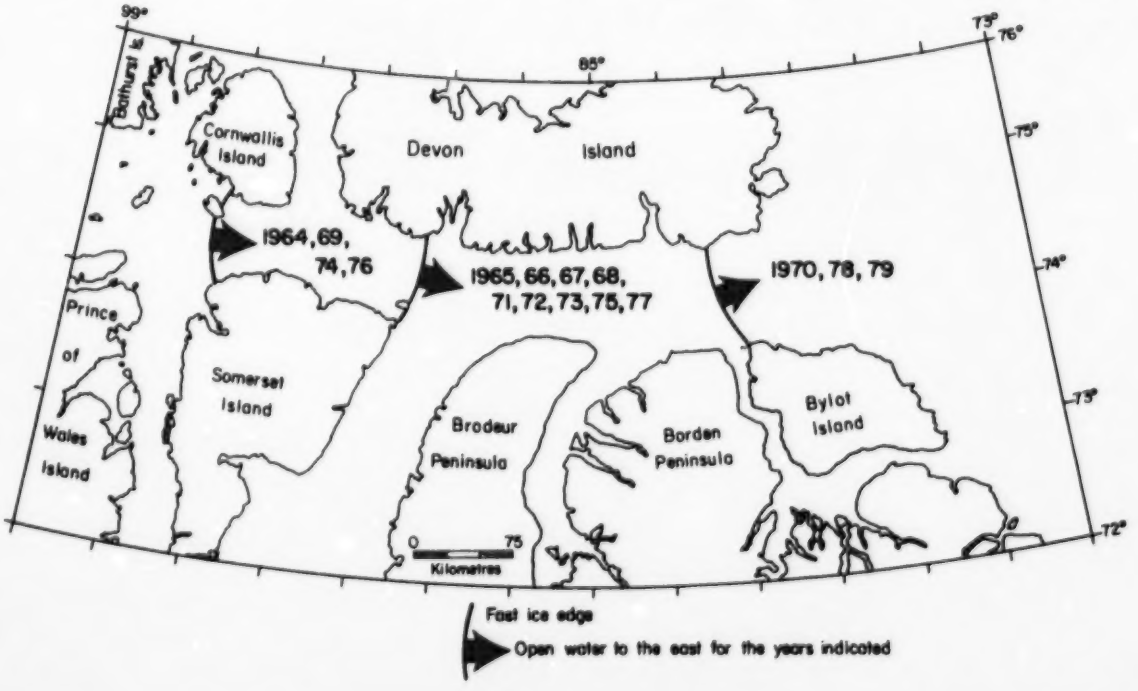


Figure 4. Locations of the fast-ice edge in Lancaster Sound from 1964 to 1979



Distribution of foraging birds at various distances from a breeding site must reflect some compromise between the availability and abundance of food in different areas and the energetic costs associated with foraging there. Habitat alterations in foraging zones may reduce reproduction at nearby colonies by affecting food availability and increasing the metabolic demand on foraging adults. Birkhead and Nettleship (1982) found that early layers are more likely to successfully rear young. If egg-laying is delayed because nutrients are converted to energy instead of being used in egg formation, then reproduction will suffer. In addition, food delivery rates to developing chicks may be lowered thereby increasing chick mortality. Thus displacement of ice edges by mechanical disruption may seriously threaten the existence of the bird colonies located in Lancaster Sound.

The survey data for the years 1974 and 1976 represent an "early spring" during which the fast-ice edge is located in Western Barrow Strait between central Cornwallis Island near Browne Island and western Somerset Island (Fig. 4). The fast-ice edge stabilized there in four years of the 16-year period described in figure 4.

For nine of these 16 years, the fast-ice edge stabilized in eastern Barrow Strait between Cape Clarence, Somerset Island near Prince Leopold Island and Maxwell Bay, Devon Island. The survey data for 1975 represent bird distributions when the ice edge stabilizes there.

The survey data for the years 1978 and 1979 represent a "late spring" during which the fast-ice edge is located in the extreme eastern portion of Lancaster Sound. During such a year, many species fail to breed and chick mortality is extremely high among those that do (Birkhead and Nettleship 1982).

2.3 The Biological Role of Ice

The role of ice in arctic marine ecosystems has been reviewed in Dunbar (1977, 1982). Sea ice has been found to be a vital and significant component in the energy cycle of marine ecosystems, particularly in coastal waters.

Several investigators have reported that ice acts to distribute organisms and nutrients throughout the water column. Buckley et al. (1979) reported wind driven upwelling along the edge of the ice pack as a result of strong winds parallel to the ice edge. Sandstrøm (1919) reported that melting ice caused upwelling at the ice edge and Hartley and Dunbar (1938) demonstrated upwelling at the face of an active glacier. The melt water either sinks under the ice or moves away from the boundary between the ice and water. Subsurface water rises to replace the melt water producing vertical currents which distribute the nutrients contained in the bottom water throughout the water column (Apollonio 1973). On the other hand, Cross (1982) found no evidence of upwelling by either mechanism at the ice edge near Pond Inlet.

Sea ice has been shown to concentrate some essential nutrients. Nitrate and phosphate accumulate in sea ice as it develops during the winter, being incorporated from the parent sea water. These nutrients are released to the surrounding water as the ice melts (Grainger 1977), and may be an important factor in the biological productivity of ice edges.

Partly as a result of these readily available nutrients, sea ice is itself a highly favorable environment for life (Butinitsky 1977). Microscopic organisms; primarily diatoms, some dinoflagellates, flagellates, ciliates, and fungi have been found in all types of polar ice (Grainger 1977, Horner 1977). Newly formed ice has few organisms; however, numbers increase as the season advances until mid-November when light probably becomes limiting (Horner and Schrader 1982). In spring the production and growth of ice algae begins in response to increasing light levels. As the ice begins to melt, these organisms are released to the surrounding water where they may form part of the spring bloom. However, the evidence is equivocal. Dunbar (1982) quotes results by Alexander and Cooney who found that the ice-edge bloom extends away from the ice a distance of 50 to 80 km. Some investigators suggest that the bloom is seeded by the released ice algae (Bursa 1961, Meguro et al. 1967). Others (Apollonio 1965, Horner 1977) suggest that the algae are merely incidental to the bloom.

A number of vertebrate species concentrate at ice edges during the arctic summer. Arctic cod (Boreogadus saida), beluga, and narwhal feed near ice edges throughout the thaw season (Bain et al. 1977, Bradstreet and Finley 1977, Bradstreet 1982). Marine birds have been most closely associated with ice edges which are a preferred feeding habitat for northern fulmars (Fulmaris glacialis) and black guillemots (Cepphus grylle). Other species such as thick-billed murres (Uria lomvia) and black-legged kittiwakes (Rissa tridactyla), although not as strongly associated with ice edges, are found there throughout the breeding season (Bradstreet 1982).

2.4 Possible Environmental Effects of Tanker Traffic on Marine Birds

Use of Lancaster Sound to transport oil from the arctic developments by ice-breaking tanker will adversely affect the survival of those marine birds that occur in that portion of the route. Birds are particularly vulnerable to oil pollution in arctic marine water where contamination by even small amounts of oil will cause mortality (Barry 1970, Pimlot et al. 1976).

The distribution of birds and the time of the year that oil appears on the surface will be more important in determining the extent to which an oil spill will affect a species than will the amount of oil released into the marine environment. The distributional information reviewed below demonstrates that large numbers of the marine birds in Lancaster Sound concentrate throughout the breeding season at ice edges in polynyas, shorereleads, cracks, and at the edge of the land-fast ice.

Oil from spills during the winter will probably surface in polynyas, shore leads, ice cracks, and melt pools in the spring through a variety of physical processes such as migration through brine channels and wind action (Mackay 1984). It also appears possible that the physical processes that produce polynyas and recurring ice edges may entrain and concentrate oil in those locations. The evidence, reviewed in Custer and Albers (1980), suggests that birds appear to avoid oil-contaminated water if it can be recognized as such and if uncontaminated water is available. However, open water may be extremely scarce during some Arctic springs (Alliston et al. 1976) and at such times all areas of open water are used.

There is no evidence to suggest that oil spill countermeasures will be even marginally effective in the Lancaster Sound region in the event of large or continued oil spills (Milne and Smiley 1978). Cumulatively, factors such as large numbers of birds congregating in relatively small areas of open water, entrainment of oil-contaminated waters in these same areas, ineffective oil spill countermeasures, and the dearth of open water during some springs, have the potential to severely deplete and perhaps extirpate a number of marine bird species.

In addition, the survival of specific populations could be further jeopardized by sub-lethal effects resulting from constant displacement of recurring ice edges by the ice-breaking ships and from chronic low level pollution of the food web associated with ice edges.

Sub-lethal effects, in contrast to deaths caused by oil contamination, cannot be easily measured. Rather, sub-lethal effects are manifested in reduced productivity (Eastin and Hoffman 1978) that can eventually lead to extinction of colonies. Decreases in reproductive rates may result from, among other things, changes in energy balance due to changes in the average relative distance of the ice edges to the breeding site, from subtle changes in the quality, quantity, or availability of food that can result from ingestion of oil or oil-contaminated food or from ingesting food species that have consumed oil or oil-contaminated food. When considering the effects of chronic low-level pollution on marine birds, it is important to consider existing levels of pollution. Lancaster Sound is a relatively uncontaminated environment. As a result, birds which have been free of any threat may now be exposed to the additional stress of pollution during the breeding season.

2.5 Knowledge Gaps

Attempts to predict the impact of a particular oil spill are hampered because of a lack of precise information on the abundance, seasonal distribution and reproductive ecology for many of the arctic marine bird species. For example, the number of black guillemots in the Canadian Arctic has been estimated to be around 60 000 pairs (McCormick et al. 1984). However, the number of breeding pairs at most sites is based on aerial surveys which in themselves produce

inadequate estimates on which to base management decisions. Similarly, numbers of breeding king and common eiders (Somateria spp.), glaucous and Thayer's gulls (Larus spp.), and arctic terns (Sterna paradisaea) are determined in the same way. The reproductive ecology of many bird species in the high Arctic must be inferred from data gathered elsewhere under different climatic regimes as few studies have been conducted on arctic reproductive ecology.

The seasonal distribution data reviewed to produce the distribution maps in the text show that data are available for many species for parts of some years and for parts of Lancaster Sound and Barrow Strait. Systematic coverage for parts of the central portion of Lancaster Sound is lacking even though it contains large fulmar colonies at Baillarge Bay, Baffin Island, and at Hobhouse Inlet, Devon Island. In addition, because of the variability among years, it is highly unlikely that the survey information that does exist is representative of most years in the Arctic.

For a few of the colonial species the knowledge base is somewhat better. The status of the thick-billed murre is best known. The size of most of the breeding colonies of the murre is known to an acceptable degree of accuracy with age structure, and survival and reproductive rates known at the Prince Leopold Island, Coburg Island and Cape Hay colonies. Further work on the thick-billed murre is in progress at other colonies in the low Arctic.

Crude estimates of total numbers of northern fulmars and black-legged kittiwakes at the colonies in Lancaster Sound are available but, with the exception of those at Bylot and Prince Leopold Islands, estimates of age structure and reproductive rates are speculative, based upon little or no on-site research.

In addition to the lack of basic knowledge of seasonal distribution and population dynamics for most species, the relationships between ice and water habitat utilization to colony size, distribution and breeding success of marine birds, especially with respect to the biological significance of polynyas, shoreleads, cracks, and the associated ice edges, are unknown. Research on these phenomena is just beginning (Stirling and Cleator 1981).

In summary, with the exception of the thick-billed murres, fulmars, and kittiwakes at Prince Leopold Island and Bylot Island, the detailed population status for most bird species in Lancaster Sound is unknown. The ecological basis for the survival of most species in the arctic marine ecosystem is unknown and the knowledge base is unavailable to monitor the natural population trends without the added complication of environmental stress from oil pollution.

3. SPECIES ACCOUNTS

3.1 Northern Fulmar

3.1.1 Phenology in Lancaster Sound

Fulmars first arrive in Lancaster Sound toward the end of April and occupy colony nesting sites shortly thereafter. About mid-May, fulmars leave the colonies for some 15 days on a pre-laying exodus before returning in early June to begin laying (Green and Nettleship 1982). Incubation takes approximately 55 days and chicks are hatched by early August. The young birds fledge in September some 50 days after hatching. Adults begin to leave the breeding colony by mid-September abandoning the chicks at their natal colony. By late October, most fulmars have departed for pelagic feeding areas that may be located in Baffin Bay, Davis Strait, or the north Atlantic (Salmonsen 1950, Fisher 1952, Brown et al. 1975).

3.1.2 Distribution in Lancaster Sound

Four large fulmar colonies containing an estimated 172 000 pairs are located in Lancaster Sound (Table 2). The colonies are located between Baillarge Bay and Elwin Inlet on Baffin Island, at Hobhouse Inlet and Cape Liddon on Devon Island, and on Prince Leopold Island. These colonies, as well as marine concentration areas, are shown in Figure 5. Areas adjacent to the colonies are used for feeding and resting throughout the breeding season, although such use may be restricted by ice conditions.

During the breeding season, fulmars in Lancaster Sound concentrate along coastal and cross-channel ice edges until these disappear. The ice edge across Lancaster Sound appears to be particularly important when it stabilizes between Cape Clarence, Somerset Island, and southwestern Devon Island. At this position the ice edge is quite near three of the four colonies shown in Figure 5. During July, dense concentrations of fulmars are found at the remnant ice edges such as those across Croker Bay, Devon Island and across Navy Board Inlet between Bylot Island and the Borden Peninsula of Baffin Island. Later in the summer, concentrations of fulmars are observed at glacier discharge areas such as Cunningham Glacier on the south coast of Devon Island. During late July and August the southeast coast of Devon Island is by far the most important feeding area for fulmars.

Figure 5. Colony locations and seasonal distribution of Northern Fulmars.

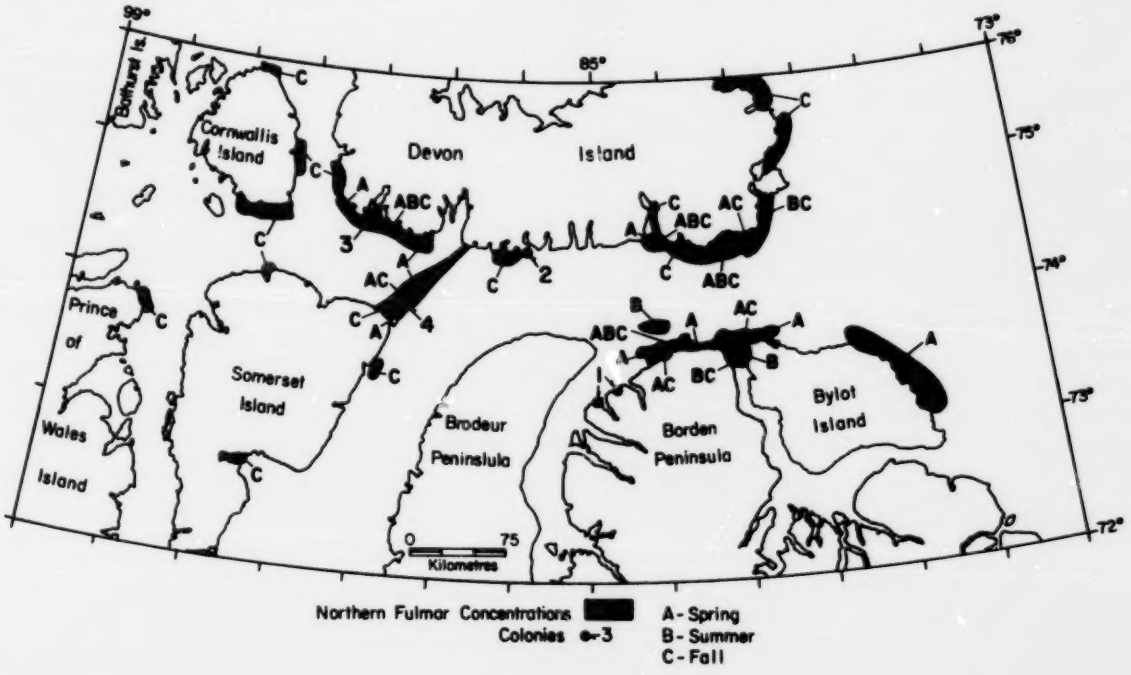


Table 2. Northern Fulmar Colonies.

Number on Map	Location	Colony Size*	Reference
1.	Baillarge Bay,	25 000 pairs	Brown et al.,
2.	Hobhouse Inlet, Devon Island	75 000 pairs (1972)	Nettleship, 1973
3.	Cape Liddon, Devon Island	10 000 pairs (1972)	Nettleship, 1973
4.	Prince Leopold Island	62 000 pairs (1977)	Gaston and Nettleship, 1981
	Total	172 000 pairs	

* During year (in brackets) of most recent survey.

3.2 Oldsquaw

3.2.1 Phenology in Lancaster Sound

Oldsquaw (Clangula hyemalis) arrive in Lancaster Sound in mid-May, with the largest influx towards the end of June. Nest initiation, near the lakes and ponds of the adjacent islands, presumably takes place during late June and most of the young have fledged by early September. However, there are no actual nesting data available for oldsquaw in Lancaster Sound. Small flocks of molting oldsquaw are found in Lancaster Sound in July, August, and part of September. During September, large numbers of oldsquaw gather throughout Lancaster Sound (Fig. 6) before migrating to wintering areas. The fall exodus probably occurs throughout the months of October and November but precise information is lacking.

3.2.2 Distribution in Lancaster Sound

Palmer (1976) suggests that oldsquaw breed throughout the high arctic, including the Lancaster Sound region, but information on specific breeding sites or numbers of breeding pairs is scarce. Throughout the season oldsquaw have been observed almost exclusively in coastal waters or just off the edge of the land-fast ice. Small flocks, of the order of several hundred birds, occur throughout the open water season along both coasts near the eastern entrance of Lancaster Sound and along the north coasts of Baffin and Bylot Islands (Fig.6). The north coast of Somerset Island near Garnier Bay is important in some years, as in 1974 when the breeding habitat was snow-covered throughout the nest initiation period of June and early July (Alliston et al. 1976). In such years, the birds may not nest and polynyas and other areas of recurring open water are used until they depart for their wintering areas.

Important molting areas include Garnier and Creswell Bays on Somerset Island, Back Bay on Prince of Wales Island, and Dundas Harbor, Croker Bay and Cunningham Glacier on Devon Island. During September, oldsquaw gather in Creswell and Garnier Bays on Somerset Island, as well as along the coastal areas near the east end of Lancaster Sound.

3.3 Eider

Two species of eider, the common eider (S. mollissima) and the king eider (S. spectabilis) occur in Lancaster Sound. Both are highly specialized diving ducks, circumpolar in distribution with considerable overlap in their ranges. The phenology and distribution of the two species in Lancaster Sound (Fig.7) are treated together because the females of the two species are nearly indistinguishable during aerial surveys.

Figure 6. Seasonal distribution of Oldsquaws.

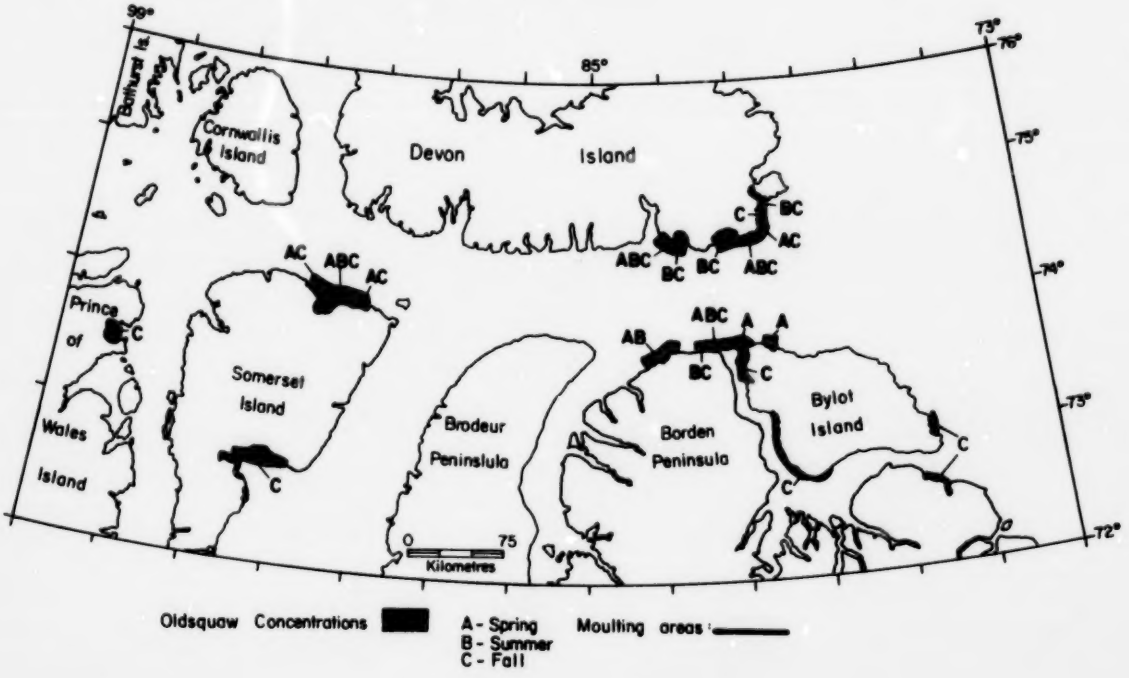
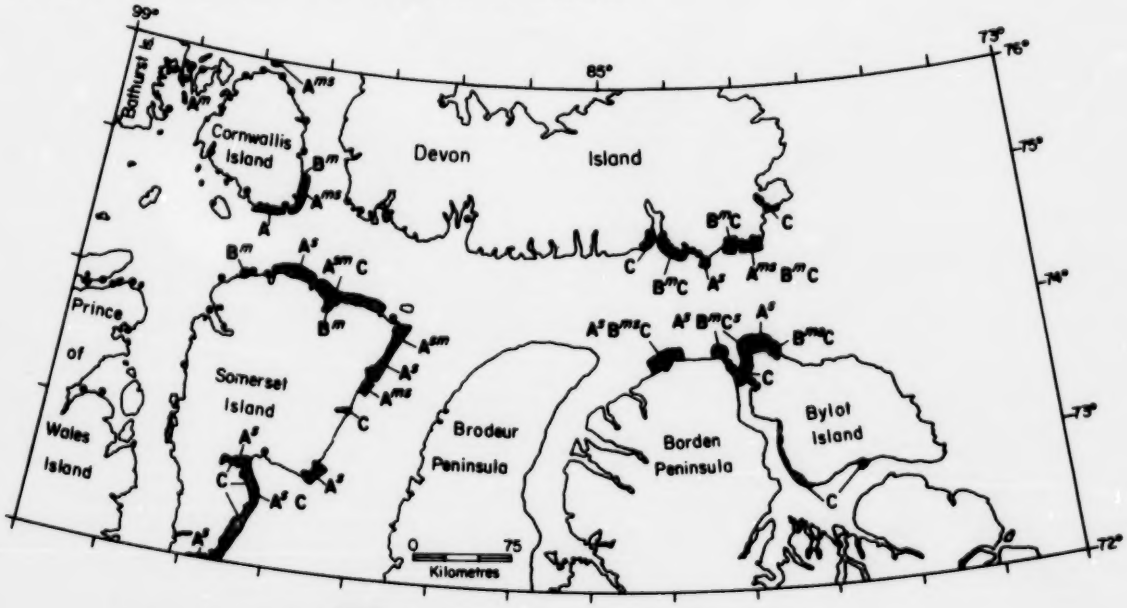


Figure 7. Seasonal distribution of Eiders.



3.3.1 Phenology in Lancaster Sound

King eiders first reach Lancaster Sound in early April, whereas common eiders arrive somewhat later in the month. However, most eiders arrive towards the end of May or in early June. Egg-laying begins in late June and hatching occurs in late July. Males do not remain in Lancaster Sound in any great numbers after females begin to incubate. By mid-August young king eiders begin to fledge and the females begin to molt.

3.3.2 Distribution in Lancaster Sound

Although both common and king eiders are believed to breed throughout the Lancaster Sound region (Bellrose 1976), few documented breeding records are available in the literature. Duvall and Handly (1948) recorded a common eider nest at Port Leopold, Devon Island and Geale (1971) recorded eight nests near Resolute Bay, Cornwallis Island. Tuck and Lemieux (1959) reported the king eider as a common nesting species on Bylot Island especially along Navy Board Inlet and Alliston et al. (1976) found two king eider nests in the same general area.

Numerous observations of eider broods and crèches (Fig. 7) throughout the Lancaster Sound region support the contention that eiders breed there. However, since broods can move considerable distances from the nesting area to feeding areas, brood observations do not necessarily indicate the presence of nesting areas nearby (Gorman and Milne 1972). Figure 7 illustrates the ubiquitous distribution of the eiders throughout the Lancaster Sound region. Eiders are widespread in the spring with concentrations reported on both sides of eastern Lancaster Sound, southeastern Cornwallis Island and along the north and east coasts of Somerset Island.

Few eiders are observed throughout most of Lancaster Sound after nest initiation and throughout the incubation period as females remain on their nests and males gather in flocks near the eastern end of the Sound before migrating to molting areas near Greenland. After the hatch in the latter part of July and the first half of August, crèches attended by molting females are observed in approximately the same locations as the spring concentrations of eider flocks.

3.4 Glaucous Gull

3.4.1 Phenology in Lancaster Sound

Glaucous gulls (L. hyperboreus), already present in small numbers by the end of April, continue to arrive throughout May. Eggs are laid during the last half of May through mid-June. Some eggs are hatched in late June and most have been hatched by mid-July. Most of the young glaucous gulls have fledged by the end of August. Migration from the area begins early in September with few birds remaining by early October.

3.4.2 Distribution in Lancaster Sound

Glaucous gulls are found along the coasts and at the edges of landfast ice throughout the Lancaster Sound region. Small breeding colonies are found on most of the coastline in the region but are particularly abundant along the north shore of Lancaster Sound (Fig. 8). The birds themselves are widely distributed until the end of July. Concentrations are again observed beginning in late July and throughout August into early September. The eastern end of Lancaster Sound along the southeast coast of Devon Island; Cape Hay on Bylot Island; and Cunningham glacier are areas of local concentrations, as are Baillarge Bay on Baffin Island; Cunningham Inlet on Somerset Island; and the southern entrance to Wellington channel (Fig. 8).

3.5 Thayer's Gull

3.5.1 Phenology in Lancaster Sound

Thayer's gulls (L. thayeri) are first observed in Lancaster Sound during the major influx of seabirds in mid-June. The return migration probably takes place in late August and early September.

3.5.2 Distribution in Lancaster Sound

Thayer's gulls are colonial, cliff-nesting birds that breed in a number of small colonies along the coasts throughout the Lancaster Sound region (Fig. 9). Most colonies consist of fewer than 100 pairs.

Thayer's gulls are observed offshore during migration, but are more coastal during the breeding season and are seldom seen far from their colonies. The birds migrate through the western Arctic to and from their wintering areas along the Pacific coast.

3.6 Ivory Gull

3.6.1 Phenology in Lancaster Sound

Flocks of ivory gulls (Pagophila eburnea) begin to appear at the eastern end of Lancaster Sound in the latter part of May (Fig. 9). By mid-June, sightings are less frequent, presumably because breeding birds are more closely tied to nest sites at that time. Flocks are again reported in mid-August off the east coast of Devon Island and at the western end of Lancaster Sound and the adjacent channels in September. Some ivory gulls may overwinter in the Lancaster Sound region; however, information on specific sightings is unavailable in the material reviewed for this report.

Figure 8. Colony locations and seasonal distribution of Glaucous Gulls.

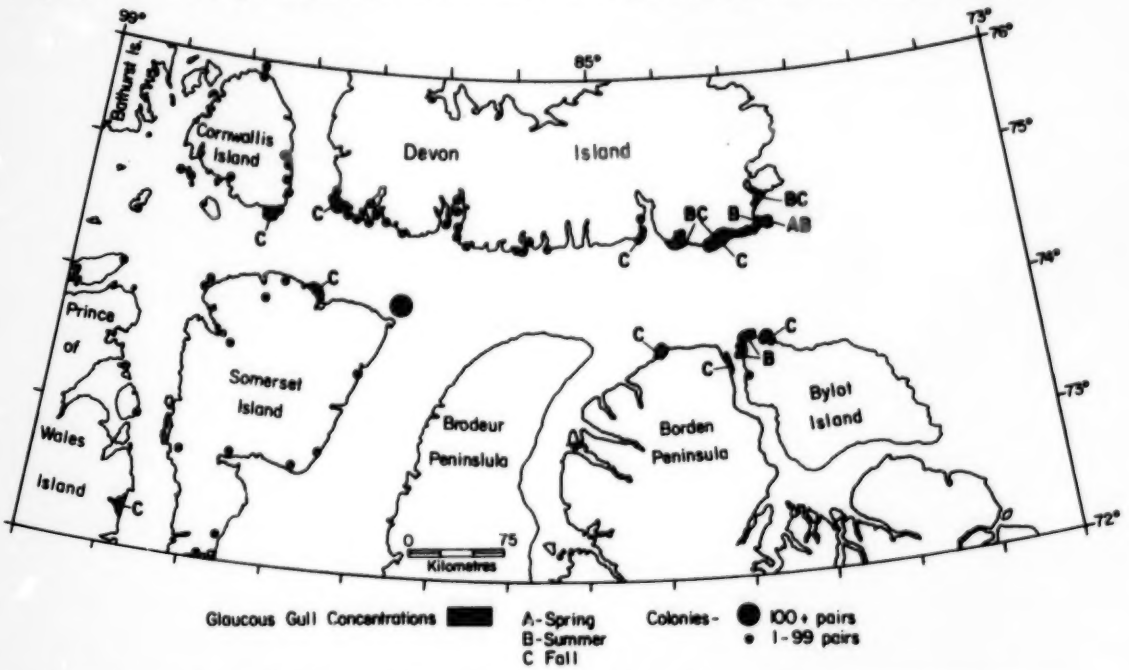
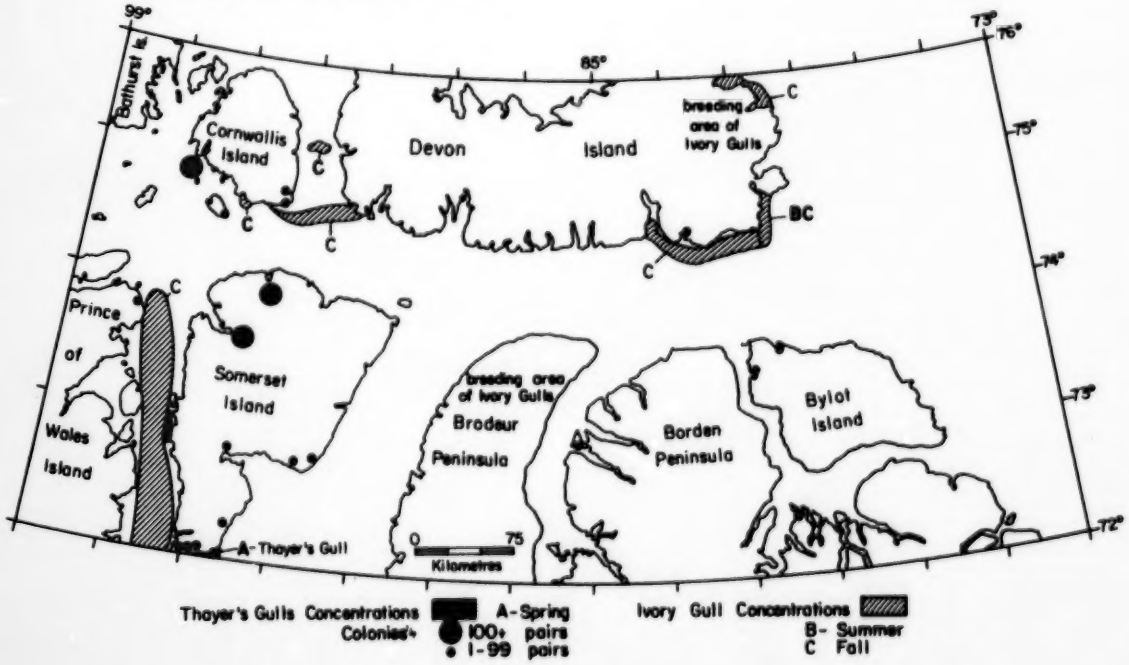


Figure 9. Colony locations of Thayer's Gulls and seasonal distribution of Thayer's and Ivory Gulls.



3.6.2 Distribution in Lancaster Sound

The breeding population of ivory gulls in the Lancaster Sound region is likely to exceed 1 000 pairs. The known colonies are small and only three of these are immediately adjacent to Lancaster Sound. The birds are found relatively concentrated, three to six birds/km², at Bethune Inlet, Cape Sharard, and Croker Bay on southeast Devon Island from late June through September (Fig.9). Concentrations have also been reported along the southern end of Wellington Channel and at Resolute Bay (Duvall and Handley 1948).

3.7 Black-legged Kittiwake

3.7.1 Phenology in Lancaster Sound

Kittiwakes first arrive in Lancaster Sound early in May but the peak migration occurs in late May and early June. Eggs are laid towards the end of June. Incubation takes approximately 30 days, and most chicks are hatched by early August. The young birds fledge the second half of August some 35 days after hatching. Adults begin to leave breeding colony by mid-September. By late October, most kittiwakes have departed for winter feeding areas.

3.7.2 Distribution in Lancaster Sound

Nine kittiwake colonies containing an estimated 88 000 pairs are located in the Lancaster Sound region; however, the colonies located at Prince Leopold Island and Cape Hay contain nearly 90 percent of the birds (Table 3). Areas adjacent to the colonies are important throughout the breeding season, although access to marine feeding areas may be restricted by ice conditions (Fig. 10). Throughout the breeding season, most kittiwakes are observed near a breeding colony. However, small flocks are also observed near Cape Joy, Baffin Island, and Cape Sharard, Devon Island in the east; and southern Cornwallis in the west. The concentrations of kittiwakes near the southwest coast of Devon Island may be non-breeding or unsuccessful breeding birds from Cape Hay or Coburg Island.

The location of the ice edge in the spring appears to influence the distribution of kittiwakes in Lancaster Sound. If it occurs across the west end of Barrow Strait, kittiwakes concentrate near southern Cornwallis Island, Griffiths Island, and southwestern Devon Island. When the ice edge stabilizes near Prince Leopold Island, kittiwakes concentrate near northeastern Somerset Island and at the Wellington Channel ice edge between southwest Devon Island and southeast Cornwallis Island.

In the fall, the distribution of kittiwakes is widespread. Small concentrations are observed along both coasts of Lancaster Sound. As well, kittiwakes have been reported in Cresswell Bay and across Lancaster Sound near Prince Leopold Island, near the usual position of the spring ice edge.

Although most observations of kittiwakes in the Lancaster Sound area have been reported in coastal waters, there have been a sufficient number of sightings of flocks offshore to suggest that during migration many kittiwakes use the central marine corridor of the Sound to reach the breeding colonies.

Table 3. Black-legged kittiwake colonies.

Number on Map	Location	Colony Size*	Reference
1.	Cape Graham Moore, Bylot Island	3 000 pairs (1957)	Tuck & Lemieux, 1959
2.	Cape Hay, Bylot Island	50 000 pairs (1957)	Tuck & Lemieux, 1959
3.	Wallaston Island	Inactive[1]	Johnson et al., 1976
4.	Prince Leopold Island	28 000 pairs (1975)	Gaston & Nettleship 1981
5.	Batty Bay, Somerset Island	2 000 pairs (1975)	Alliston et al., 1976
6.	Cape Rinnell, Somerset Island	100 pairs (1974)	Davis et al., 1974
7.	Browne Island	2 000 pairs (1975)	Alliston et al., 1976
8.	Separation Point, Cornwallis Island	Inactive[2]	Alliston et al., 1976
9.	Washington Point, Baillie-Hamilton Island	2 000 pairs (1975)	Alliston et al., 1976
	Total	88 000 pairs	

* During year (in brackets) of most recent survey
1 This colony was active in 1973 (Brown et al. 1975)
2 This colony contained 125 pairs in 1972 (Nettleship 1973)

3.8 Arctic Tern

3.8.1 Phenology in Lancaster Sound

Arctic terns begin to arrive in Lancaster Sound early in June with the peak migration occurring towards the end of the month. Based on data from Jones Sound (Prach, Unpubl. data), the first eggs are laid in early July. Incubation takes approximately 20 days and most chicks are hatched by mid-August. The young birds fledge in early September, some 25 days after hatching. Almost all of the birds have left the region by late September.

3.8.2 Distribution in Lancaster Sound

Arctic terns breed in small colonies, usually in freshwater habitats, on the islands surrounding Lancaster Sound. Population size is unknown and reports of colony locations in the region are rare. Colonies have been reported at Croker Bay, near Resolute Bay, Cornwallis Island, at Creswell Bay, Somerset Island, on Bathurst Island, and on small islands in McDougall Sound (Fig. 11). During the breeding season Arctic terns feed relatively close to their breeding colonies. As these are usually small and inconspicuous, few concentrations of terns have been recorded. Flocks appear in coastal areas in mid-August. Southeast Devon Island; southeast Cornwallis Island; and Creswell Bay, Somerset Island are reported to be particularly important prior to migration.

3.9 Thick-billed Murre

3.9.1 Phenology in Lancaster Sound

Thick-billed murres begin to arrive in Lancaster Sound toward the end of April. The peak of migration occurs during the first week of May at Bylot Island, and at Prince Leopold Island in early June if open water is available. Egg-laying begins at Prince Leopold in late June. Incubation takes 31-34 days. Chicks fledge up to 30 days after hatching, most at between 18 and 23 days of age, towards the end of August. By early September, the young accompanied by an adult, have begun a swimming migration to wintering areas off west Greenland. It is not known when during the swimming migration the young birds begin to fly (Gaston and Nettleship 1981).

3.9.2 Distribution in Lancaster Sound

Three murre colonies containing an estimated 240 000 pairs are located in Lancaster Sound (Table 4). The colonies are located at Prince Leopold Island, and at Cape Graham Moore and Cape Hay on Bylot Island (Fig. 12). As with most other seabird species in Lancaster Sound, areas adjacent to the colonies are important throughout the breeding season. Murres forage up to 100 km from their colonies and concentrate at ice edges when these are available. After the break-up of land-fast ice they are found in association with floating pack ice.

Figure 10. Colony locations and seasonal distributions of Black-legged Kittiwakes.

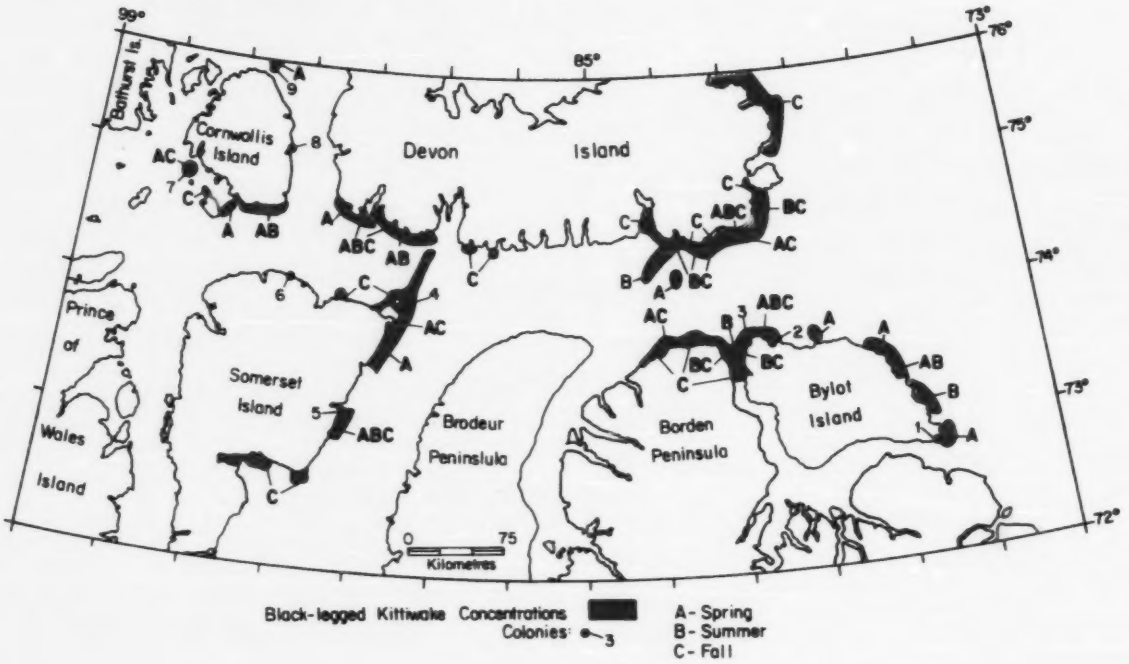
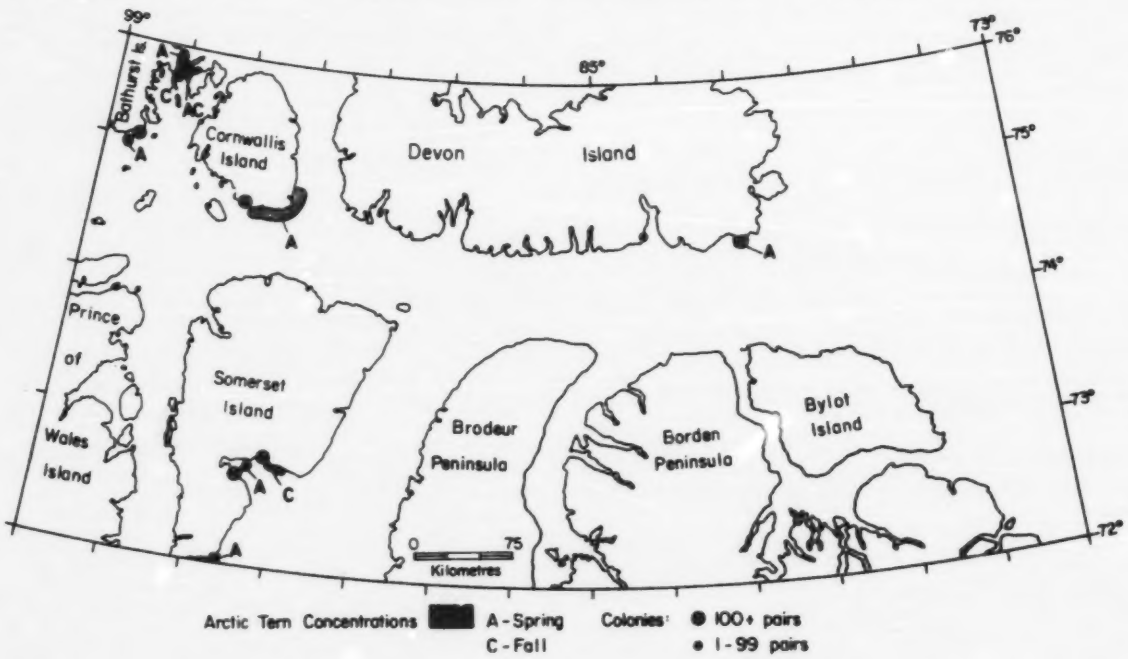


Figure 11. Colony locations and seasonal distribution of Arctic Terns.



Murres that have been observed offshore in Lancaster Sound in May are probably those that breed at Prince Leopold Island. During the breeding season, thick-billed murres in Lancaster Sound concentrate preferentially along coastal and cross-channel ice edges until these break up. The ice edge across Lancaster Sound appears to be particularly important, presumably to Prince Leopold Island birds, when it stabilizes between Cape Clarence, Somerset Island and Cape Liddon, Devon Island. Later in the breeding season, the birds appear to be concentrated at the colonies (Gaston and Nettleship 1981).

3.10 Dovekie

3.10.1 Phenology in Lancaster Sound

Dovekies (Alle alle) do not breed in Canada; however, very large numbers -- on the order of 10 million pairs -- breed in the Thule district of north west Greenland. The birds move into the eastern end of Lancaster Sound apparently on their way to the breeding colonies. Dovekies are the most abundant bird in Lancaster Sound during mid-May. They occur well offshore and are associated with areas of heavy ice cover rather than the actual edge of the pack ice. A few of the birds remain in the area all summer, at least until September, and have been seen near Prince Leopold Island and Resolute Bay, Cornwallis Island. There are small concentrations in northwest Baffin Bay late in June of presumed failed breeders from Greenland and there is a major offshore migration in late August and early September. Immediately after they leave the Thule area in late August, dovekies may fly first to the pack-ice in central Baffin Bay and along the east coast of Baffin Island where nonbreeding birds probably spend much of the summer. Few birds remain north of Bylot Island after mid-September, and northwest Baffin Bay is probably clear of dovekies by the end of September (Fig. 13).

3.11 Black Guillemot

3.11.1 Phenology in Lancaster Sound

Black guillemots begin to arrive in Lancaster Sound early in May when many are observed offshore, presumably heading for breeding sites elsewhere. Assuming that the breeding phenology of black guillemots in Lancaster Sound is similar to other arctic areas, egg-laying is completed by early July. Incubation takes from 30-35 days and chicks are hatched by the end of July. The birds begin to disperse from the breeding areas after the young fledge in late August, some 35 days after hatching. Most adults and chicks leave western Lancaster Sound by the end of August but a few have been observed farther east in late September. A few black guillemots overwinter in polynyas and other areas of open water near reported breeding areas.

3.11.2 Distribution in Lancaster Sound

Black guillemots breed in small colonies in the talus of cliffs along most of the Lancaster Sound coastline, with the apparent exception of southeast Devon Island. The size of the breeding population is unknown, but is perhaps on the order of 20 000 pairs. Black guillemots have been observed concentrated in some 28 locations in Lancaster Sound and connecting waterways (Fig. 14).

Twenty-three of the observed concentrations are located in western Lancaster Sound, Barrow Strait and Prince Regent Inlet. Of these, only four are reported to contain more than 100 breeding pairs: Prince Leopold Island, 4 000 pairs; Batty Bay to Fury Point on Somerset Island, 1 600 pairs; Cape Clarence, Somerset Island, 200 pairs; Elwin Bay, Baffin Island, 125 pairs.

Marine areas adjacent to the colonies are important throughout the breeding season. At this time guillemots concentrate preferentially in coastal waters along the edge of the land-fast ice. Guillemots are able to exploit very small areas of open water; thus in contrast to most other seabirds, access to feeding areas is not restricted by heavy ice conditions.

Figure 12. Colony locations and seasonal distribution of Thick-billed Murres.

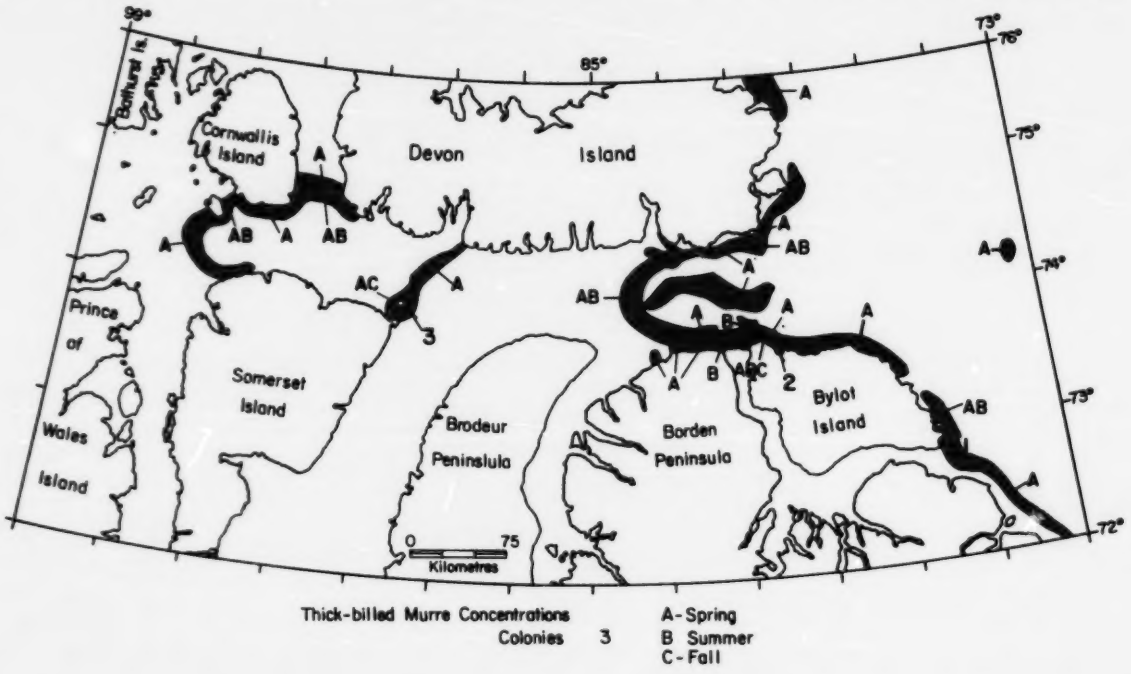


Table 4. Thick-billed Murre Colonies.

Number on Map	Location	Colony Size	Reference
1.	Cape Graham Moore, Bylot Island	20 000 pairs	Brown et al., 1975
2.	Cape Hay, Bylot Island	140 000 pairs	Nettleship, 1980
3.	Prince Leopold Island	80 000 pairs	Nettleship and Gaston, 1978
	Total	240 000 pairs	

Figure 13. Seasonal distribution of Dovekies.

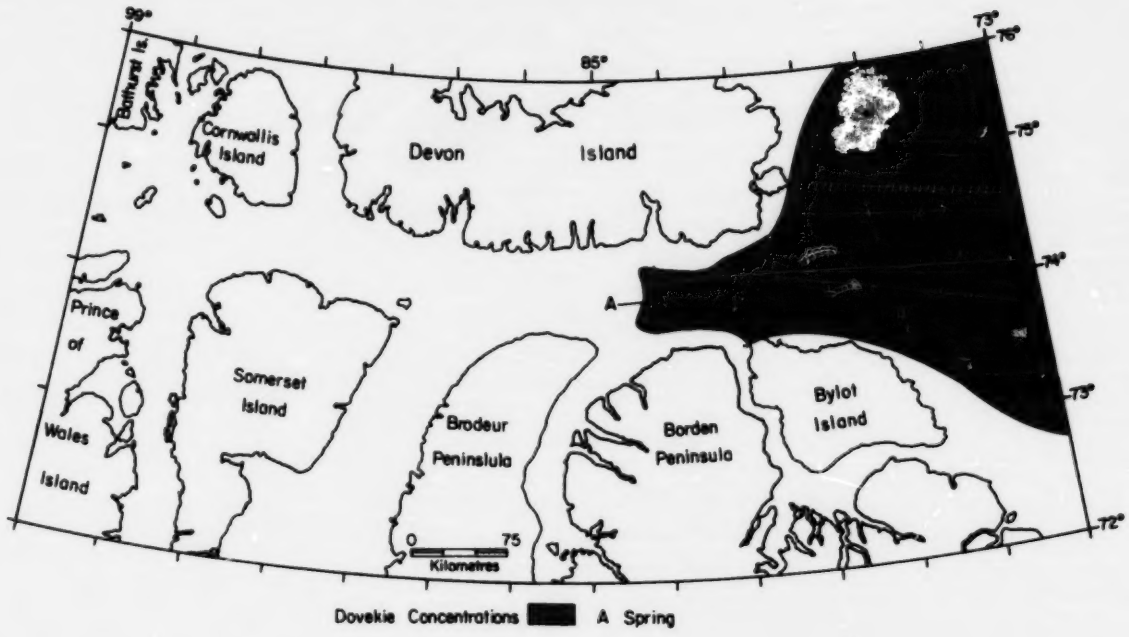
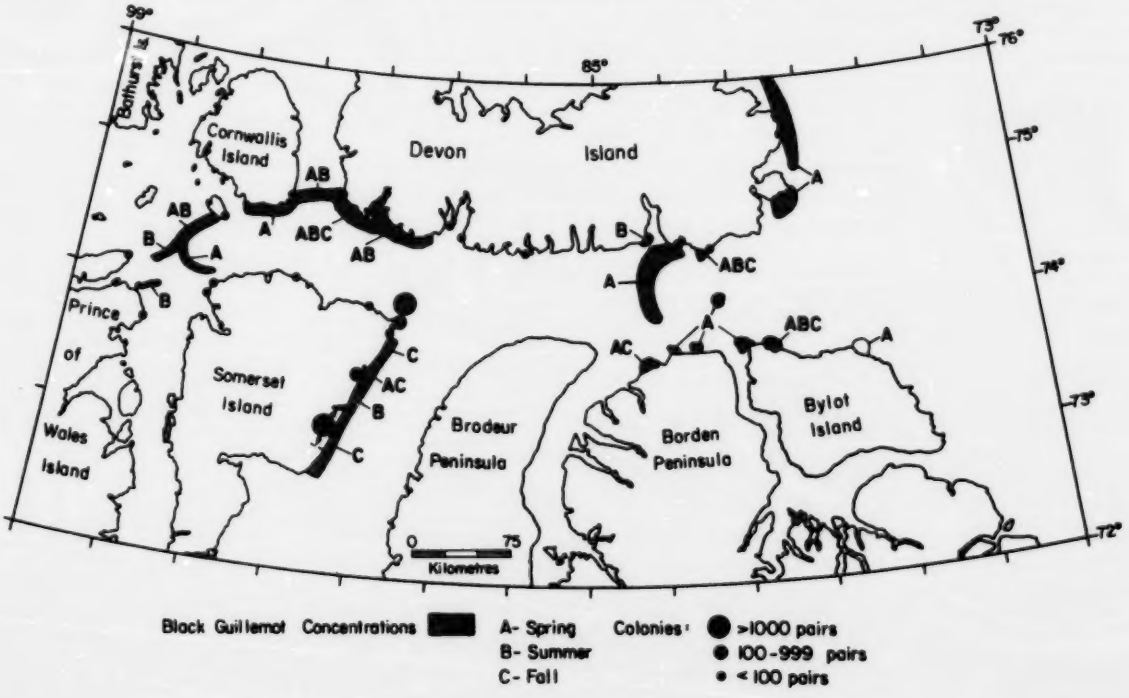


Figure 14. Colony locations and seasonal distribution of Black Guillemots.



4. LITERATURE CITED

Alliston, W.G., Bradstreet, M.S., Mclaren, M.A., Davis, R.A., and W.J. Richardson. 1976. Numbers and Distribution of birds in the central District of Franklin, N.W.T. June-August 1975. Unpbl. Rpt. by LGL Ltd. for the Polar Gas Proj. 584 pp.

Apollonio, S. 1965. Chlorophyll in Arctic sea ice. Arctic 18:118-122.

Apollonio, S. 1973. Glaciers and nutrients in arctic seas. Science 180:481-483.

Bain, M., Thompsons, D., Foy, M., and W. Griffiths. 1977. Marine ecology of fast-ice edges in Wellington Channel and Resolute Passage, N.W.T. Unpbl. Rep. by LGL Ltd. for the Polar Gas Proj. 262 pp.

Barry, T. W. 1970. Likely effects of oil in the Canadian Arctic. Marine Pollution Bulletin. Arctic Issue.

Bellrose, F.C. 1976. Ducks, Geese, and Swans of North America. Stackpole Books, Harrisburg, Pa. 544 pp.

Birkhead, T.R., and D.N. Nettleship. 1982. The adaptive significance of egg size and laying date in thick-billed murres (Uria lomvia). Ecology 63(2):300-306

Bradstreet, M.S.W. 1982. Occurrence, habitat use, and behaviour of seabirds, marine mammals, and arctic cod at the Pond Inlet ice edge. Arctic 35:28-40

Bradstreet, M.S.W., and K.J. Finley. 1977. Distribution of birds and marine mammals along fast-ice edges in Barrow Strait, N.W.T. Unpbl.Rep. by LGL Ltd. for the Polar Gas Project. 315 pp.

Brown, R.G.B., Nettleship, D.N., Germian, P., Tull, C.D., and T. Davis. 1975. Atlas of eastern Canadian seabirds. Can. Wildl. Serv., Ottawa. 220 pp.

Buckley, J.R., Gammelsrød T., Johannessen, J.A., Johannessen, O.M., and Røed, L.P. 1979. Upwelling: Oceanic structure at the edge of the arctic pack ice in winter. Science 203:165-167.

Buinitsky, V.K. 1977. Organic life in sea ice. Pp. 301-306 in Polar Oceans. M.J. Dunbar (Ed.). Arct. Inst. of North Am., Calgary.

Bursa, A. S. 1961. The annual oceanographic cycle at Igloolik in the Canadian Arctic. II. The phytoplankton. J. Fish. Res. Board Can. 18: 563-615.

Cross, W.E. 1982. Occurrence, habitat use, and behavior of seabirds, marine mammals, and arctic cod at the Pond Inlet ice edge. Arctic 35:13-27.

Custer, W.C. and P.H. Albers. 1980. Response of captive, breeding mallards to oiled water. J. Wildl. Manage. 44(4):915-918.

Davis, R. A., Bradstreet, M., Holdsworth, C., McLaren, M., and W. J. Richardson. 1974. Studies of the numbers and distribution of birds in the Central Canadian Arctic - 1974: A preliminary report. Unpbl. Rpt. by LGL for the Polar Gas Proj. 238 pp.

Dunbar, M.J. (ed.). 1977. Polar oceans. Arct. Inst. of North Am., Calgary. 682 pp.

Dunbar, M.J. 1982. Physical causes and biological significance of polynyas and other open water in sea ice. Pp. 29-44 in Polynyas in the Canadian Arctic. Stirling, I. and H. Cleator (Eds.) Can. Wildl. Serv. Occas. Pap. No. 45. Ottawa

Duvall, A.J. and C.O. Handley. 1948. Second wildlife reconnaissance of the eastern Canadian Arctic. Spec. Rep. Can. Wildl. Serv., Ottawa. C.W.S.C. 8. 168 pp.

Eastin, W.C. and D.J. Hoffman. 1978. Biological effects of petroleum on acquatic birds. Pp 561-568 in Conf. Proc. Assessment of ecological impacts of oil spills. Am. Inst. of Bio. Sciences. Keystone, Colorado

Fisher, J. 1952. The Fulmar. London. William Collin Sons & Co., Ltd. 496 pp.

Gaston, A. J. and D. N. Nettleship. 1981. The Thick-billed Murres of Prince Leopold Island. Can. Wildl. Serv. Monog. Ser. No. 6. Ottawa. 350 pp.

Geale, J. 1971. Birds of Resolute, Cornwallis Island, N.W.T. Can. Field-Nat. 85:53-59

Gorman, M.L. and H. Milne. 1972. Crèche behavior in the common eider. Ornis Scand. 3:21-25.

Grainger, E.H. 1977. The annual nutrient cycle in sea ice. Pp. 285-300 in Polar oceans. M.J. Dunbar (Ed.). Arct. Inst. of North Am., Calgary

Greene, A., and D.N. Nettleship. 1982. Attendance patterns of northern fulmars at Prince Leopold Island, Northwest Territiories, Canada. Unpbl. Rpt. by Can. Wildl. Serv. Dartmouth, N.S. 31 pp.

Hartley, C.H. and M. J. Dunbar. 1938. On the hydrographic mechanisms of the so-called brown zones associated with tidal glaciers. J. Mar. Res. 1:305-311.

Horner, R.A. 1977. History and recent advances in the study of ice biota. Pp.269-284 in Polar Oceans. M.J. Dunbar (Ed.). Arct. Inst. of North Am., Calgary

Horner, R. and G.C. Schrader. 1982. Relative contributions of ice algae, phytoplankton, and benthic microalgae to primary production in nearshore region of the Beaufort Sea. Arctic 35:485-503.

Johnson, S. R., Renaud, W. E., Richardson, W. J., Davis, R. A., Holdsworth, C., and P. D. Hollingdale. 1976. Aerial surveys of birds in eastern Lancaster Sound. Unpbl. Rpt. by LGL for Norlands Petroleum Ltd. 365 pp.

Mackay, D. 1984. The fate and behaviour of oil in cold climates. Unpbl. Rpt. for Environment Canada. 124 pp.

Mansfield, A.W. 1983. The effects of vessel traffic in the Arctic on marine mammals and recommendations for future research. Dept. Fisheries and Oceans. Tech. Rept. No. 1186. Ste. Anne de Bellevue. 97 pp.

McCormick, K.J., Adams, M.E., Stephenson, C.J., and A.S. Goodman. 1984. Key migratory bird terrestrial habitat sites in the Northwest Terrritories. Unpbl. Rpt. Can. Widl. Ser. Edmonton. 175 pp.

McLaren, P. L. 1982. Spring migration and habitat use by seabirds in eastern Lancaster Sound and western Baffin Bay. Arctic 35:88-111

Meguro, H., Ito, K., and H. Fukushima. 1967. Ice flora (bottom type): A mechanism of primary production in polar seas and the growth of diatoms in sea ice. Arctic 20:114-133.

Milne, A.R., and B.D. Smiley. 1978. Offshore drilling in Lancaster Sound: Possible environmental hazards. Dept. Fisheries and Environment, Sidney B.C. 95 pp.

Nettleship, D.N. 1973. Seabird colonies and distributions around Devon Island and vicinity. Arctic 27:95-103

Nettleship, D.N. and A.J. Gaston. 1978. Patterns of pelagic distribution of seabirds in western Lancaster Sound and Barrow Strait, Northwest Territories, in August and September 1976. Can. Wildl. Ser. Ottawa. 40 pp.

Palmer, R. S.(Ed.) 1976. Handbook of North American birds Waterfowl, Vol 3. New Haven and London. Yale University Press. 560 pp.

Pimlot, D., Brown, D., and K. Sam. 1976. Oil Under Ice. Can. Arc. Res. Com. Ottawa. 178 pp.

Salmonsen, F. 1950. The birds of Greenland. Parts I and II. Ejnar Munksgaard, Copenhagen. 604 pp.

Sandstrøm, J.W. 1919. The hydrodynamics of Canadian Atlantic waters. Canadian Fisheries Expedition 1914-15 Dep. of the Naval Ser. Can. Pp 221-343.

Stirling, I., and H. Cleator (Eds.). 1981. Polynyas in the Canadian Arctic. Can. Wildl. Serv. Occas. Pap. No. 45, Ottawa. 73 pp.

Tuck, L.M. and L. Lemieux. 1959. The avifauna of Bylot Island. Dansk Orn. Foren. Tidsskr. 53:137-154